ECE 20001 Spring 2020

Midterm Exam 2

Last Name: Michelusi **First Name:** Nicolò

Student ID: _____

Section:

- ◯ 2:30 Mayer
- ◯ 12:30 Kildishev
- ◯ 12:30 Irazoqui
- ◯ 7:30 Cui
- ◯ 1:30 Michelusi

I have neither given nor received unauthorized assistance on this exam.

_____

Instructions:

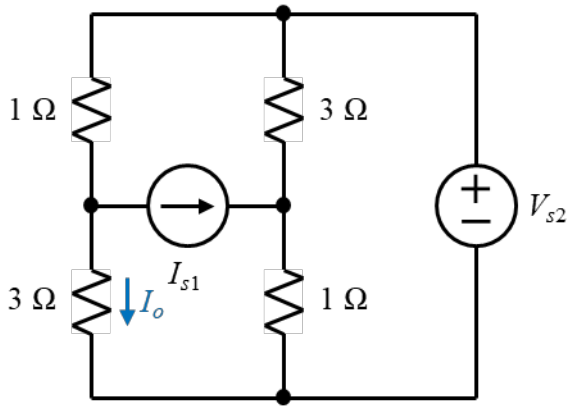
1. Adhere to the Purdue Honor Pledge. Sign the statement above before turning in your exam.
2. Print your name and Student ID. Fill in the bubble corresponding to your section. Print the last two digits of your Student ID in the boxes at the bottom right corner of each odd-numbered page.
3. This is a closed-book, closed-note exam. No study materials should be visible or accessible during the exam. Use of a TI-30X IIS calculator is allowed.
4. For each question, determine the answer and then select the closest choice. Mark the choice by filling in the bubble completely: ●. Only the marked choice will be scored. Your work to determine an answer may be reviewed as part of an academic integrity assurance process.
5. All questions are equally weighted but are not equally difficult – manage your time wisely.
6. If you need extra space for a question, raise your hand and a proctor will provide an extra sheet of paper.
7. You have 60 minutes to complete the exam.
8. You must turn in (a) all pages of this exam and (b) any extra sheet(s) provided by a proctor.

Learning Outcomes

i. An ability to analyze linear resistive circuits. (Q01 – Q07)
ii. An ability to analyze first-order linear circuits with sources and/or passive elements. (Q08 – Q15)
iii. An ability to analyze electronic circuits with diodes and transistors.

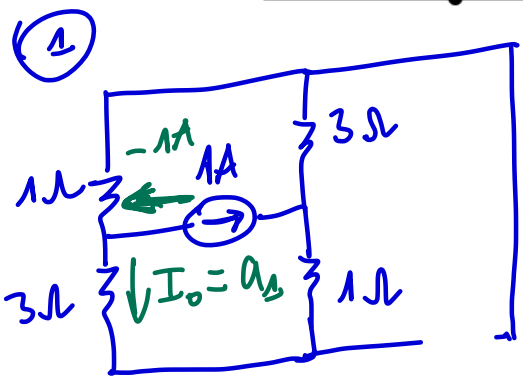
For the questions on this page consider the following network output equation:

$$I_o = a_1 I_{s1} + a_2 V_{s2}$$



1. What is the value of a_1?

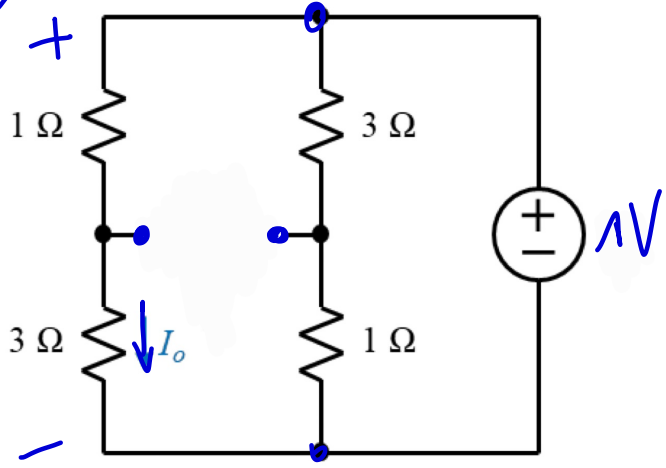
○ −1	○ ¼
○ −¾	○ ⅓
○ −½	○ ½
○ −⅓	○ ¾
● −¼	○ 1



$$a_1 = \frac{1/3}{\frac{1}{1} + \frac{1}{3}} \cdot (-1) = -\frac{1}{4} A$$

2. What is the value of a_2?

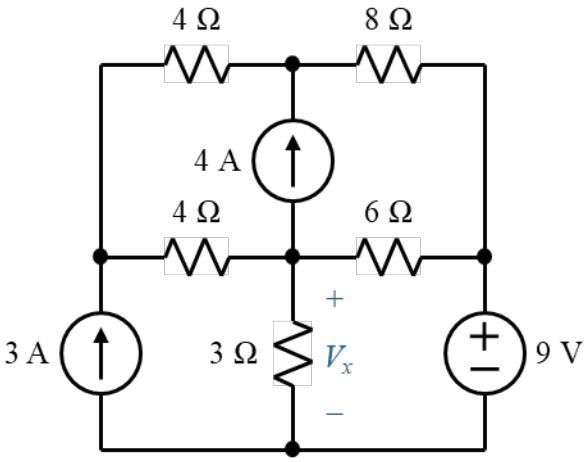
○ −1	● ¼
○ −¾	○ ⅓
○ −½	○ ½
○ −⅓	○ ¾
○ −¼	○ 1

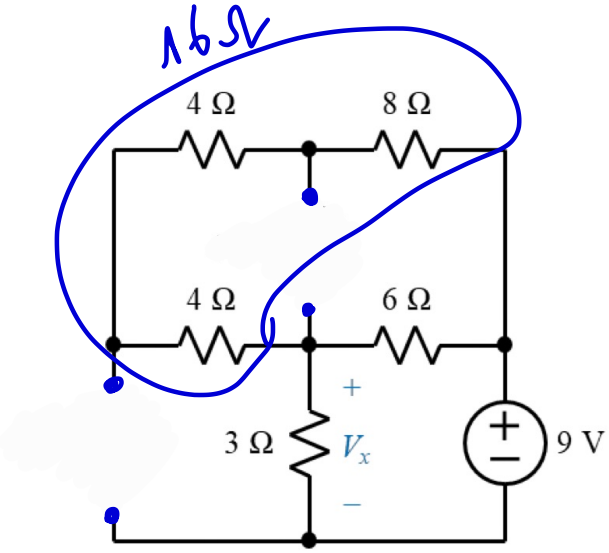


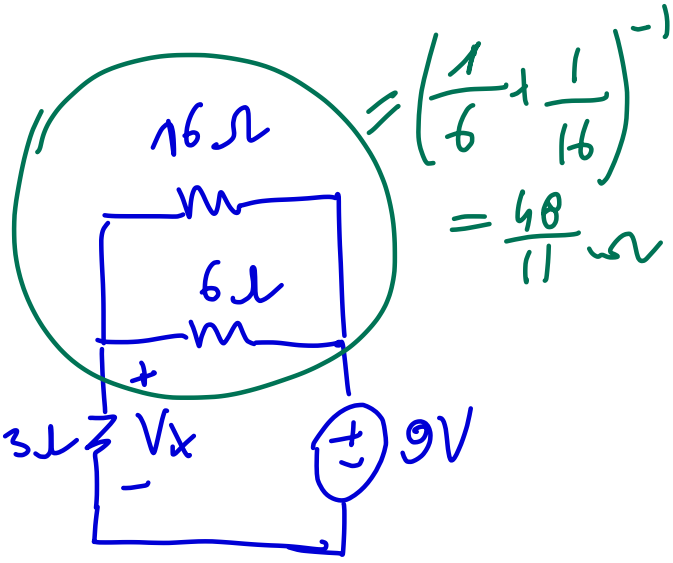
$$a_2 = I_o = \frac{1V}{4\Omega} = \frac{1}{4}$$

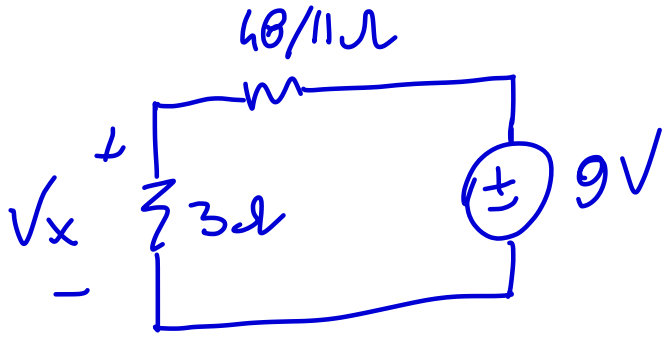
3. What is the component of V_x due to the 9 V source in volts?

- ○ 0
- ○ 2.333
- ○ 3.556
- ● 3.667
- ○ 4
- ○ 4.8
- ○ 4.87
- ○ 5.333
- ○ 9
- ○ 11.222



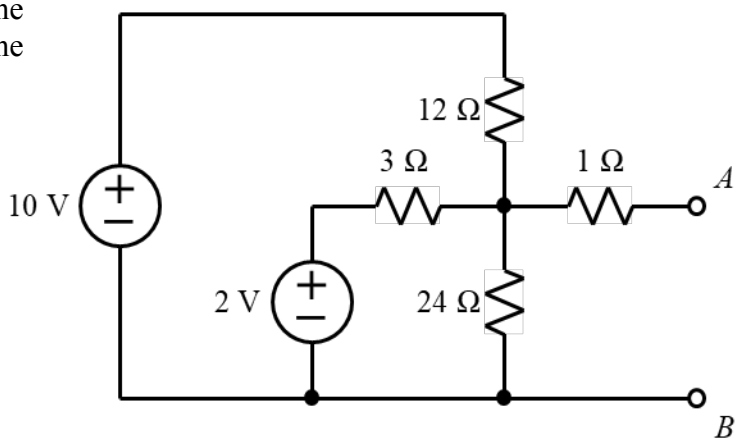






$$V_x = \frac{3}{3+\frac{48}{11}} \cdot 9V = \frac{11}{3}V \approx 3.67V$$

For the questions on this page determine the Thevenin equivalent network looking into the *A*-*B* terminal pair.

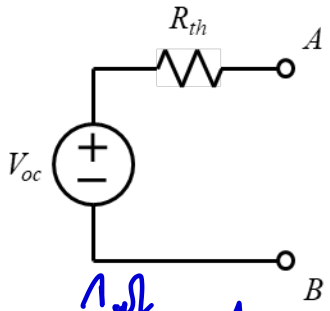


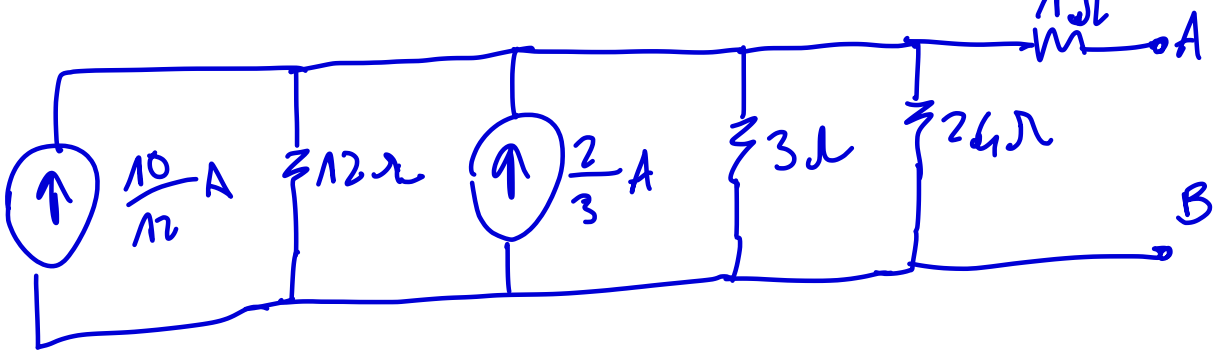
4. What is the value of V_{oc} in volts?

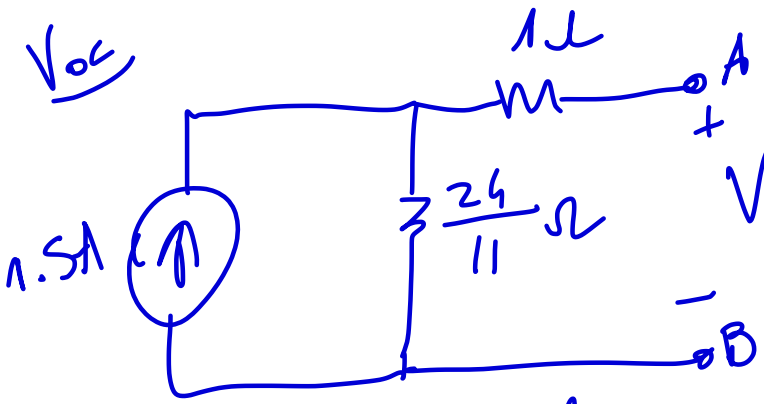
○ 0	○ 2
○ 1	● 3.273
○ 1.455	○ 6
○ 1.778	○ 6.667
○ 1.818	○ 10

5. What is the value of R_{th} in ohms?

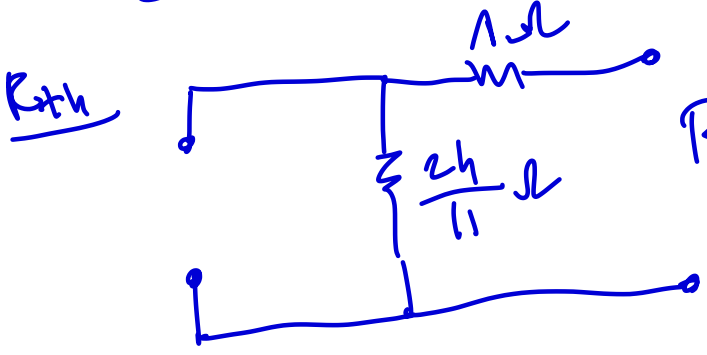
○ 0	○ 4
○ 0.686	○ 9
○ 1	○ 13
● 3.182	○ 25
○ 3.667	○ 40





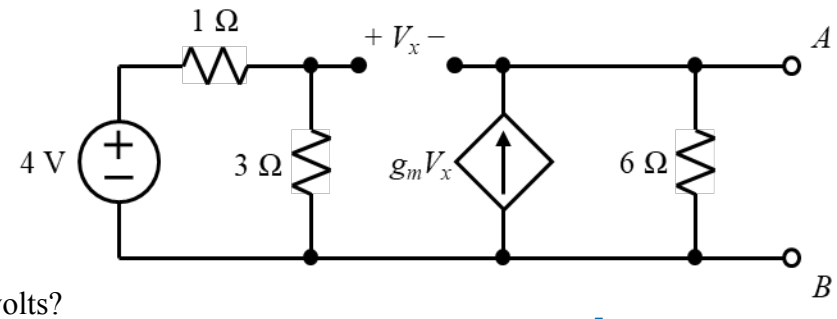


$V_{OC} = \frac{24}{11}\,\Omega \cdot 1.5A = \frac{36}{11}\,V \approx 3.27V$



$R_{th} = \frac{24}{11} + 1 = \frac{35}{11}\,\Omega \approx 3.18\,\Omega$

For the questions on this page determine the Thevenin equivalent network looking into the *A*-*B* terminal pair when $g_m = 2$ S.

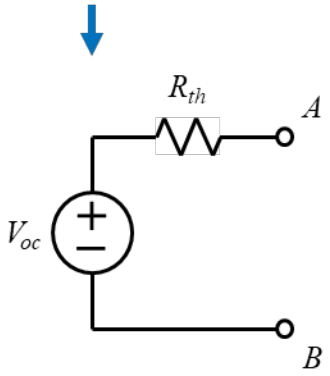


6. What is the value of V_{oc} in volts?

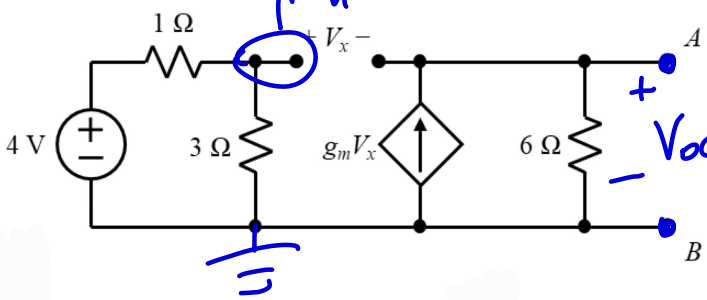
○ -4	○ 0.231
○ -3	● 2.769
○ -2.769	○ 3
○ -0.231	○ 4
○ 0	○ 36

7. What is the value of R_{th} in ohms?

○ 0	○ 2.167
● 0.462	○ 4
○ 0.5	○ 6
○ 1.5	○ 6.5
○ 2	○ 8



V_{oc}



$\frac{3}{4} \cdot 4V = 3V$

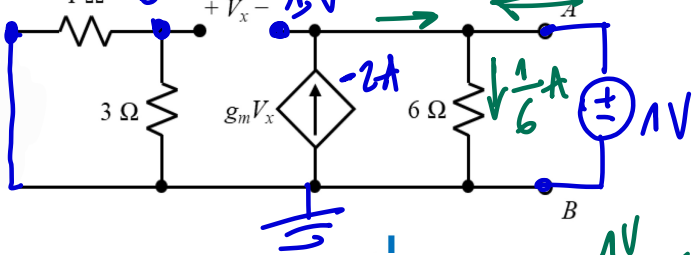
$V_{oc} = 6\Omega \cdot g_m V_x = 12 V_x$

$= 12(3 - V_{oc})$

$V_x = 3 - V_{oc}$

$V_{oc} = 36 - 12 V_{oc} \Rightarrow V_{oc} = \frac{36}{13} V \approx 2.77V$

R_{th}



$V_x = 0 - 1 = -1\,V$

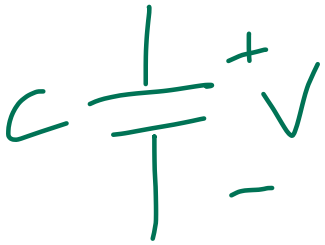
$I_x = \frac{1}{6} - (-2)$

$= \frac{13}{6} A$

$R_{th} = \frac{1V}{I_x} = \frac{6}{13}\Omega \approx 0.46\Omega$

8. What is the capacitance in farads for a capacitor that stores simultaneously 4 C of charge and 5 J of energy?

○ 0.4	○ 2.5
○ 0.625	○ 3.42
○ 1	○ 4
○ 1.25	○ 5
● 1.6	○ 20



$Q = C \cdot V = 4$

$E = \frac{1}{2} \cdot C \cdot V^2 = 5$

$CV = 4$

$CV \cdot V = 10 \Rightarrow V = 2.5\,V$

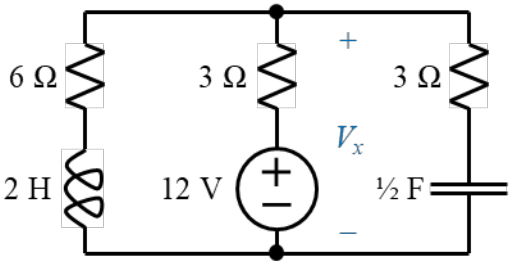
4

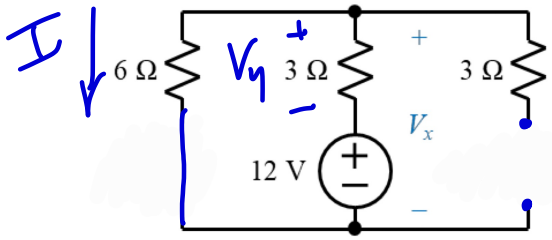
$CV = 4 \Rightarrow C = \frac{4}{V} = \frac{4}{2.5}\,F$

$= 1.6\,F$

9. What is the value of V_x in volts? Assume that the circuit is operating in the steady state.

- ○ 0
- ○ 2
- ○ 3
- ○ 4
- ○ 6
- ● 8
- ○ 9
- ○ 12
- ○ 15
- ○ 16



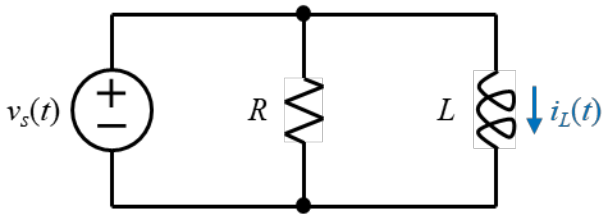


$V_y = -3 \cdot I = -4V$

$I = \frac{12}{3+6} = \frac{4}{3} A$

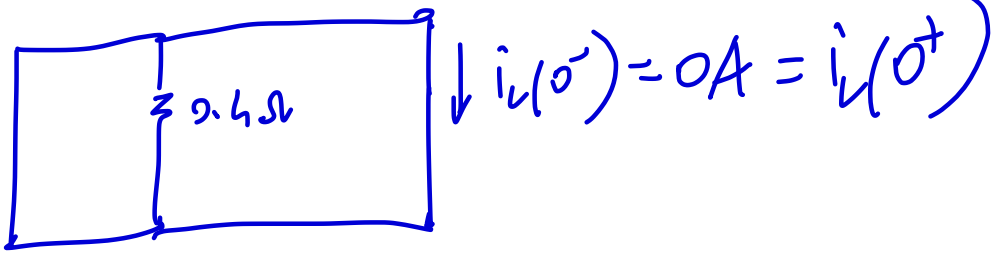
$\Rightarrow V_x = 12V + (-4V) = 8V$

10. What is the value of $i_L(t)$ in amperes at $t = 0.6$ s if $R = 0.4\ \Omega$, $L = 0.5$ H, and $v_s(t) = 3u(t)$ V?



○ 0	○ 2.859
○ 0.9	○ 3
○ 1.144	● 3.6
○ 1.8	○ 4.641
○ 1.856	○ 7.5

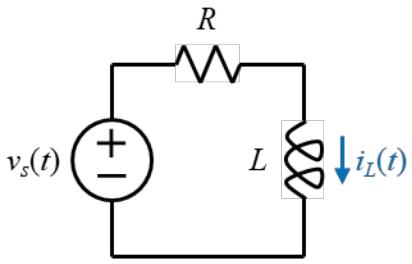
$t = 0^-$ (circuit was at steady state)



$$i_L(0.6) = i_L(0^+) + \frac{1}{L}\int_0^{0.6} v_s(t)\,dt = 0 + \frac{1}{0.5}\int_0^{0.6} 3\,dt$$

$$= 2 \cdot 3 \cdot 0.6\ A = 3.6A$$

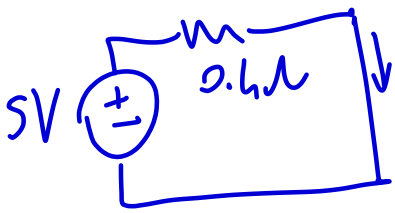
For the questions on this page consider the inductor current response $i_L(t)$ when $R = 0.4\ \Omega$, $L = 0.5$ H, and $v_s(t) = 5u(-t) + 3u(t)$ V.



11. What is the value of $i_L(t)$ in amperes at $t = 0$?

- ○ 0
- ○ 2
- ○ 2.5
- ○ 3
- ○ 5
- ○ 6
- ○ 7.5
- ○ 10
- ● 12.5
- ○ 20

At $t=0^-$

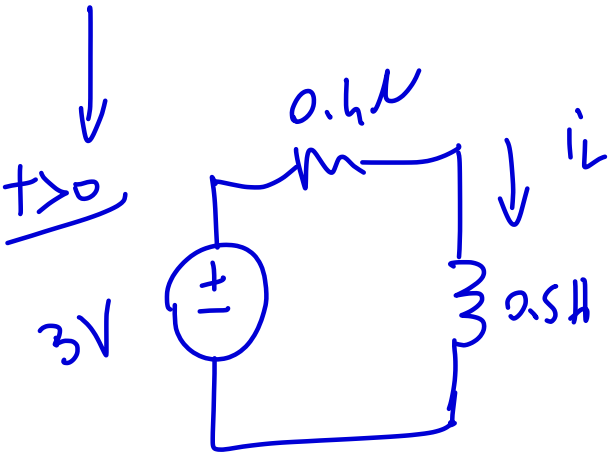


$i_L(0^-) = \frac{5}{0.4}$ A

$= 12.5$A

12. What is the value of $i_L(t)$ in amperes at $t = 0.6$ s?

- ○ 0
- ○ 2.859
- ○ 3.1
- ○ 4.406
- ○ 7.5
- ○ 7.735
- ○ 7.749
- ○ 9.747
- ● 10.594
- ○ 12.5



$\tau = \frac{L}{R} = 1.25$ s

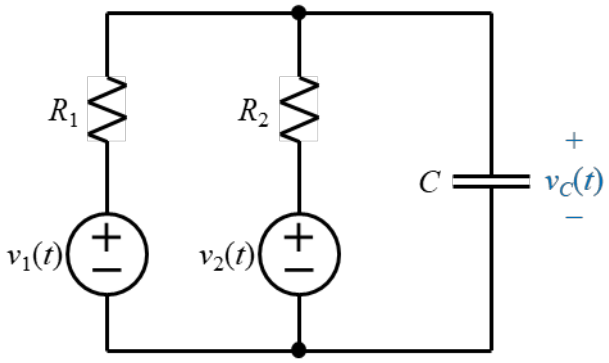
$i_L(\infty) = \frac{3}{0.4}$ A $= 7.5$A

$i_L(t) = 7.5 + (12.5 - 7.5) \cdot e^{-\frac{t}{1.25}}$

$= 7.5 + 5 \cdot e^{-t/1.25}$

$i_L(0.6) = 7.5 + 5 \cdot e^{-\frac{0.6}{1.25}} \approx 10.59$ A

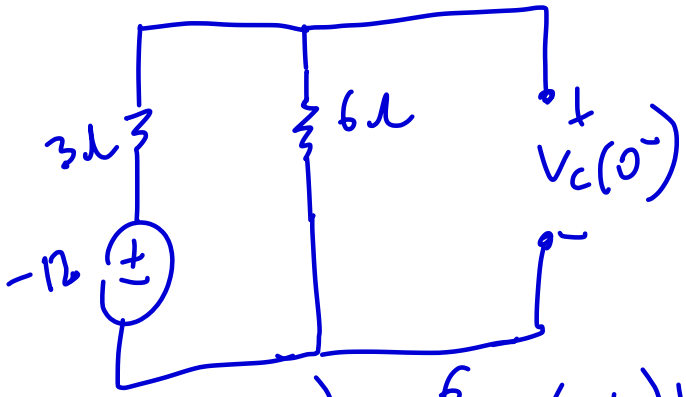
For the questions on this page consider the capacitor voltage response $v_C(t)$ when $R_1 = 3\ \Omega$, $R_2 = 6\ \Omega$, $C = 0.25$ F, $v_1(t) = -12u(-t)$ V, and $v_2(t) = 15u(t)$ V.



13. What is the value of $v_C(t)$ in volts at $t = 0$?

○ -12	○ 1.5
● -8	○ 2.5
○ -4	○ 5
○ 0	○ 10
○ 1	○ 15

At $t=0^-$, steady state



$$v_c(0^-) = \frac{6}{3+6}(-12)\,V = -8\,V$$

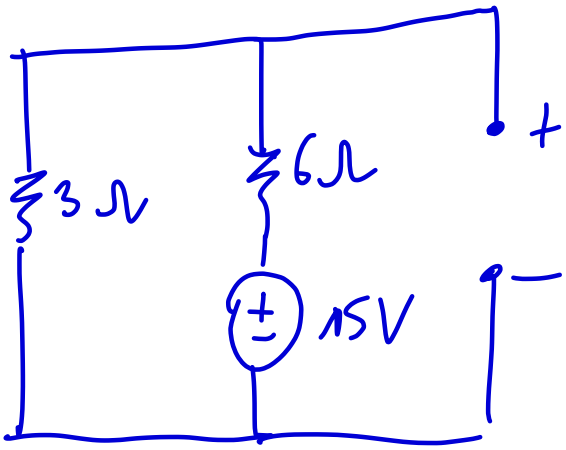
14. What is the value of $v_C(t)$ in volts as $t \to \infty$?

○ -12	○ 1.5
○ -8	○ 2.5
○ -4	● 5
○ 0	○ 10
○ 1	○ 15

15. What is the value of $v_C(t)$ in volts at $t = 0.75$ s?

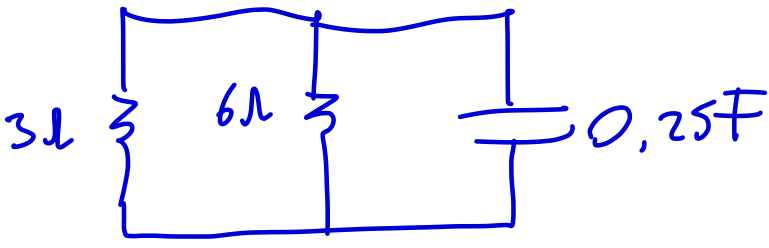
○ -8	○ 3.884
○ -2.885	○ 4.968
○ -1.785	○ 5
● 2.099	○ 7.901
○ 3.241	○ 15

At $t \to \infty$



$$v_c(\infty) = \frac{3}{3+6}\cdot 15\,V = 5\,V$$

Q15 c



$R_{eq} = 2\Omega \Rightarrow \tau = C \cdot R_{eq} = 0.5\,s$

$t > 0$

$$v_c(t) = 5 + (-8-5)e^{-t/0.5}$$

$$= 5 - 13 \cdot e^{-2t}$$

$$v_c(0.75) = 5 - 13 \cdot e^{-1.5} \simeq 2.10\,V$$